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A Case Study in Innovative Outreach—Combining Training, Research, and Technology Transfer to Address Real-World Problems

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Outreach, training, technology transfer, and research are often treated as programmatically distinct activities. The interdisciplinary and applied aspects of the Superfund Basic Research Program offer an opportunity to explore different models. A case study is presented that describes a collaborative outreach effort that combines all of the above. It involves the University of California's Davis and Berkeley program projects, the University of California Systemwide Toxic Substances Research and Teaching Program, the U.S. Navy's civilian workforce at the former Mare Island Naval Shipyard, Vallejo, California (MINSY), a Department of Defense (DoD) Environmental Education Demonstration Grant program, and the Private Industry Council of Napa and Sonoma counties in California. The effort applied a Superfund-developed technology to a combined waste, radium and polychlorinated biphenyl contamination, stemming from a problematic removal action at an installation/restoration site at MINSY. The effort demonstrates that opportunities for similar collaborations are possible at DoD installations. — *Environ Health Perspect* 106(Suppl 4):1065–1067 (1998). *http://ehpnet1.niehs.nih.gov/docs/1998/Suppl-4/1065-1067chang/abstract.html*

Key words: outreach, technology transfer, PCBs, soil remediation, steam injection, base closure

The National Institute of Environmental Health Sciences (NIEHS)/U.S. Environmental Protection Agency (U.S. EPA) Superfund Basic Research Program (SBRP) has an unusual mission: conducting multidisciplinary research on highly applied problems within the framework of a basic biomedical core. At the same time the SBRP is committed to the timely transfer of its research findings to organizations and groups that contribute to protection of human and environmental health. In many organizations, including Superfund, the research program efforts are divorced or organizationally separated from training efforts. A case is made that these activities can be successfully combined and additional partnering opportunities may present themselves in the future as additional Department of Defense (DoD) facilities are closed. In the following commentary, a case study of a combined research, training, and outreach effort is recounted. The SBRP played an important part in bringing together resources from several organizations to address real-world problems at the now-closed Mare Island Naval Shipyard (MINSY) in Vallejo, California.

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Abbreviations used: bp, boiling point; DoD, Department of Defense; DRMO, Defense Reutilization and Material Organization; MINSY, Mare Island Naval Shipyard, Vallejo, CA; NIEHS, National Institute of Environmental Health Sciences; PCBs, polychlorinated biphenyls; SBRP, Superfund Basic Research Program; UCB, University of California, Berkeley; UCD, University of California, Davis; U.S. EPA, U.S. Environmental Protection Agency.

Background

The historic MINSY occupied 5646 acres at the juncture of the Napa River and San Pablo Bay, California, which in turn connects to nearby San Francisco Bay, California. The military base was selected for closure in July 1993. During the past several years MINSY has been undergoing a rapid program of removal, remediation, and restoration to prepare it for civilian reuse. MINSY was the first naval shipyard established on the West Coast (ca 1849). A wide range of industrial processes were used there and consequently their associated toxic contaminants were released unwittingly. Among the contaminants discovered late in the closure process (ca 1996) at a site known as the Defense Reutilizaton and Material Organization (DRMO), essentially a scrap yard dating back to World War II, were radium, polychlorinated biphenyls (PCBs), and other heavy metal contaminants. The combined waste (naturally occurring radioactive material + hazardous organic compounds) was not a result of a release from the nuclear cycle, but of disposal of items with radium-containing paints commonly used for illumination. However, the DRMO soil was a problem for either treatment or disposal because at the time there were no existing facilities permitted to treat or dispose of combined waste in the United States.

Concurrent with the base closure announcement, the former Director of the Office of Safety Environment and Health, Doug Ghiselin, requested that the University of California, Davis ([UCD]; Davis, CA) undertake an effort to retrain naval and nuclear systems engineers in environmental engineering. Since 1994, over 80 of the shipyard's civilian nuclear systems engineers have undergone a graduate retraining program conducted by the Department of Civil and Environmental Engineering and the University Extension at UCD. At the conclusion of their coursework, the engineers have either assisted in MINSY's environmental cleanup activities or been placed in new careers at other federal facilities, many as a direct result of the additional environmental training. When the cocontamination issue at the DRMO site became a disposal problem, the university was asked to assist with development of suggestions for and evaluation of potential solutions.

Among the government outreach activities that the NIEHS/U.S. EPA SBRP has supported are a symposium on "Transfer of [Superfund] Basic Research to Waste Site Remediation" (*1*) and a collaborative project undertaken by scientists within the University of California, Berkeley ([UCB], Berkeley, CA) and UCD program projects. The cocontamination problem provided an opportunity for UCB and UCD scientists and engineers to team together with the Navy to train their engineers in a state-of-the-art remediation technology and thus foster technology transfer to the DoD. Lack of experience, cost, and reliability data are impediments to new technology transfer, along with lack of incentive for basic researchers, consultants, or remedial project managers to employ new technologies (*2*). Laboratory-steam injection technology was recognized as one possible means of separating the radium from the PCBs on the contaminated soil, but it has not yet been tested for that specific purpose. If a treatability study were to be successfully undertaken, a technology would become available that allowed separation of the contaminants and subsequent treatment and disposal of the separated streams.

Approach to the Problem

As an environmental engineer, I was familiar with UCB colleague Kent Udell's Superfund-initiated work on cyclic steam-injection technology. Accordingly, Udell proposed a joint effort that provided for both training and determining the feasibility of using steam injection to clean up the combined waste. From March to May of 1996, Udell, assisted by a Superfund trainee from UCB (Michael Itamura), presented the principles of cyclic steam injection to a class of 20 Navy civilian engineers and technicians participating in MINSY's remediation activities. Topics included a brief history of application of steam injection technology in industry and to waste site remediation; introduction to physical processes associated with steam application, e.g., enthalpy considerations, condensation, evaporation, and steam as a displacement fluid; characteristics of media and contaminants that impact the applicability of steam; methods for monitoring steam front movement; basic design calculations and exercises; introduction to operation of a pilot-scale unit. In a companion laboratory course that extended over the next year, a UCD Superfund trainee (Pingkuan Di), several MINSY engineers and technicians, a DoD fellowship recipient working on a Master's of Science project (Mark Hutchinson), and I carried out laboratory and bench-scale studies. Design of an *ex situ* bench-scale reactor for steam injection and testing of the method on semivolatile surrogate waste-contaminated soil was completed (*3*). The effort was undertaken with the joint sponsorship of a DoD environmental education grant to UCD that covered costs of course instruction and provided a graduate fellowship, NIEHS/U.S. EPA SBRP grants to UCB and UCD that provided laboratory support as part of outreach to the DoD and traineeship support, and supplemental funds provided by a grant to the Private Industry Council of Napa and Solano Counties for worker retraining. Three additional technologies that are not within the focus of this commentary were also evaluated with funding provided by the Naval Sea Systems Command.

Results

In laboratory-scale testing conducted at UCD, 150°C steam was passed through an Aroclor 1260 PCB-contaminated soil sample similar to that found at the DRMO site. The soil was placed in the oven compartment of a gas chromatograph. Using a 10:1 mass ratio of steam to soil, the results indicated a high removal efficiency of PCBs from the soil (Figure 1). Analyses were provided by the UCD Superfund Program Project Analytical Core. Scientists at UCD also carried out a radium mobility study to ascertain whether radium became mobilized when steam passed through cocontaminated soil. These studies revealed that the PCB could be mobilized from the soil with only a small portion of radioactivity carried through the system—sufficiently small that the condensate resulting from steam treatment of cocontaminated soil was not considered radioactive waste.

The successes at the laboratory scale warranted a bench-scale treatability study at MINSY. Under the guidance of the UCD and UCB collaborators, the engineers-in-training designed and constructed a pressure vessel/steam generator at the shipyard from salvaged equipment. They used the bench-scale unit to test soil that had been spiked to concentrations of 100 ppm with two relatively innocuous surrogate compounds. The two surrogates, octadecane (boiling point [BP] 317°C) and chrysene (BP 440°C), fairly represented a range of Aroclor 1260 boiling points (275–385°C). The steam generator was operated at 150°C and about 60 lb/in^2. Soil samples of approximately 10 kg were used. The bench-scale unit removed approximately 84% of the octadecane from the soil after 24 steam cycles (steam-to-soil mass ratio of ~11), and approximately 86% of the chrysene after 48 cycles (steam-to-soil mass ratio of ~20). These results were sufficiently promising to warrant further treatability studies with PCB-contaminated soil. Those studies are currently underway at MINSY.

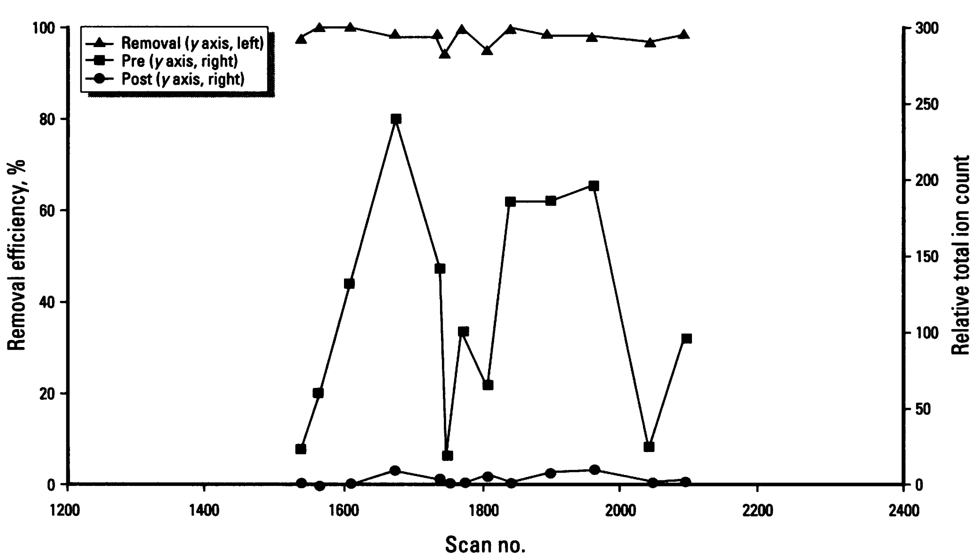

Figure 1. Gas chromatography/mass spectrometry scans of PCB extract illustrating removal of PCBs by steam through MINSY soil containing approximately 290 mg/kg PCB. Qualitative analysis based on selected PCB congener peaks from five to nine chlorine atoms. Temperature = 150°C; approximately 10:1 steam/soil mass ratio. Adapted from Chang et al. (*3*).

A Point of View

Outreach can take many forms: It can be training, technology transfer, technical assistance to government agencies, dissemination of information to the public or other stakeholders, science education, and so forth. The case study presented here was also outreach, but it combined many elements of outreach into a single project. Not only did it illustrate that it is possible to successfully combine retraining efforts of experienced engineers to treat real problems at DoD facilities with Superfund-developed technologies, but that DoD facilities offer opportunities for demonstrating or applying new technologies for which it might otherwise be difficult to obtain permission or funding to apply at conventional Superfund sites. It provides a model for further collaborative efforts among the NIEHS/U.S. EPA SBRP and the DoD.

REFERENCES AND NOTES

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